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SOIL-VEGETATION CORRELATIONS IN RIPARIAN AND EMERGENT WETLANDS, LYON COUNTY, NEVADA

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PREFACE

The National Ecology Research Center of the U.S. Fish and Wildlife Service (FWS) is supporting a series of field research studies to document relationships between hydric soils and wetland vegetation in selected wetlands throughout the United States. This study is one of that series. It is a continuation of the FWS effort, begun by Wentworth and Johnson (1986), to develop a procedure using vegetation to designate wetlands based on the indicator status of wetland vegetation as described by the FWS "National List of Plants that Occur in Wetlands" Reed (1986a). This list classifies all vascular plants of the United States (U.S.) into one of five categories according to their natural frequency of occurrence in wetlands. Concurrent with the development of the wetland plant list, the Soil Conservation Service (SCS) developed the "National List of Hydric Soils" SCS (1985a). Studies supported by the National Ecology Research Center quantitatively compare associations of plant species, designated according to their hydric nature using the Wentworth and Johnson (1986) procedure, with the hydric nature of soils according to their designation on the SCS hydric soils list. The studies are being conducted across moisture gradients at a variety of wetland sites throughout the U.S. Several studies have been modified to obtain concommitant information on groundwater hydrology.

These studies were conceived in 1984 and implemented in 1985 in response to internal planning efforts of the FWS. They parallel, to some extent, ongoing efforts by the SCS to delineate wetlands for Section 1221 of the Food Security Act of 1985 (the swampbuster provision). The SCS and FWS provided joint guidance and direction in the development of the Wentworth and Johnson (1986) procedure, and the SCS is currently testing a procedure that combines hydric soils and the Wentworth and Johnson procedure for practical wetland delineation. The efforts of both agencies are complimentary and are being conducted in close cooperation.

The primary objectives of these studies are to (1) assemble a quantitative data base of wetland plant community dominance and codominance for determining the relationship between wetland plants and hydric soils; (2) test various delineation algorithms based on the indicator status of plants against independent measures of hydric character, primarily hydric soils; and (3) test, in some instances, the correlation with groundwater hydrology. The results of these studies also can be used, with little or no supplementary hydrologic information, to compare wetland delineation methods of the Corps of Engineers (1987) and the Environmental Protection Agency (Sipple 1987).

Any questions or suggestions regarding these studies should be directed to: Charles Segelquist, 2627 Redwing Road, Creekside One Building, Fort Collins, Colorado, 80526-2899, phone FTS 323-5384 or Commercial (303) 226-9384.

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ACKNOWLEDGEMENTS

I thank Warren Archer and John Schelling, soil scientist and district conservationist with the Soil Conservation Service, respectively, for assistance with soil identifications, verifications, and soil boundary delineations. I appreciate the help of Patty Moen, Mary Peacock, and Jan Richards, technicians with the Desert Research Institute, Biological Sciences Center, for their field assistance during vegetation sampling. Patty also helped with data synthesis and graphics, while Mary also helped with data analysis. Harold Klieforth, Desert Research Institute, Atmospheric Sciences Center, provided climatic data. My appreciation is extended to the Truckee-Carson Irrigation District, Marty Harris of the Carson River Ranch, and the Nevada Division of Parks for permission to conduct this study on private and public properties. This study was funded by the National Ecology Research Center, U.S. Fish and Wildlife Service, Fort Collins, CO.

INTRODUCTION

Wetlands are among the fastest disappearing natural ecosystems in the United States (Mitsch and Gosselink 1986). Approximately 45% of the wetlands in the United States were lost between presettlement times and the late 1970's (Shaw and Fredine 1956; Frayer *et al.* 1983; Tiner 1984). Reasons for the loss of these wetlands primarily include urban expansion, agriculture, flood-control, and other public works projects. As a consequence, assessment and management of the Nation's remaining wetlands have become major concerns for many public agencies and private organizations.

Cowardin et al. (1979) define wetlands as transitional ecosystems found at the interface between terrestrial and aquatic systems, where the substrate is at least periodically saturated or covered by water. In addition, they state that wetlands must have one or more of the following three attributes:

> *(1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.*

Cowardin et al. (1979) define hydrophytes as plants that grow in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content. A list of hydrophytes for the United States has been compiled by Reed (1986b). A wetland indicator value was assigned to each species on this list, indicating its frequency of occurrence in wetlands. Using these indicator values, Wentworth and Johnson (1986) developed a wetland delineation system for the U.S. Fish and Wildlife Service (FWS).

The Soil Conservation Service (1985b) defines a hydric soil as soil that in its undrained condition is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation. Lists of hydric soils have been compiled by the States and by the Soil Conservation Service.

The FWS designed and currently is funding ecological studies in wetlands throughout the United States; the objectives of these studies are to test the Wentworth and Johnson wetland delineation system, and to test the relationship between wetland plant dominance and hydric soils. This study is one of a series of soil-vegetation correlation studies from a wide variety of wetland types designed to test the FWS delineation methodologies. Riparian and emergent wetlands were ranked relatively high in priority by the FWS for

study because they have received scant attention in the past yet offer examples of unique wetland types. The specific objectives of this study were to: (1) test the hypothesis that riparian and emergent wetland plants as identified by the FWS dominate vegetation associations on hydric soils as defined by the Soil Conservation Service; (2) test the Wentworth and Johnson wetland delineation system; and (3) initiate a data base on the vegetation, soils, and hydrology of two different wetlands in Nevada.

DESCRIPTION OF STUDY AREAS

This study was conducted in riparian and emergent wetlands in Lyon County, Nevada (Figure 1). Three study areas in riparian wetlands were selected along the lower Carson River in the Carson River Hydrographic Basin (Nevada Division of Water Resources 1974). Two of these study areas are located on the floodplain just above Lahontan Reservoir, where the soils are artificially inundated an average 10 weeks in springtime when the reservoir reaches maximum capacity (U.S. Geological Survey 1986). Two additional study areas in emergent wetlands were selected in the Carson Desert north of the Carson River sites. These wetlands lie within the West Central Hydrographic Region (Nevada Division of Water Resources 1974). Names, locations, ownership, and soil types present at the five study areas are provided in Table 1.

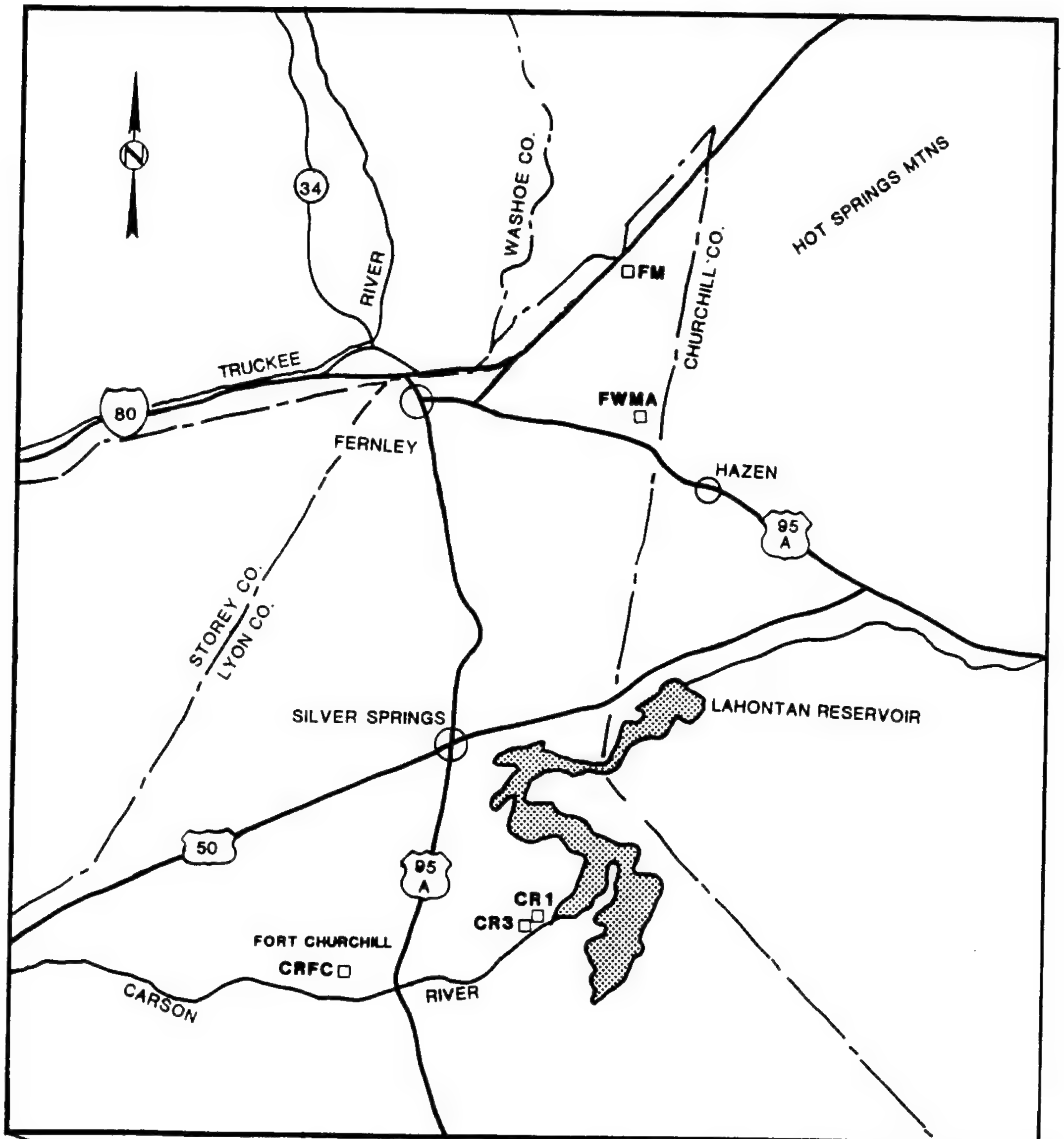
Climatic variation in western Nevada is large. The Sierra Nevada produces a significant rain shadow over the western Great Basin resulting in precipitation minima less than 100 mm yr^{-1}. At Lahontan Reservoir, Fort Churchill, and Fernley, the 30-year mean annual precipitation is 113, 135, and 139 mm, respectively. Summers are moderately hot with mean annual July temperatures at Lahontan and Fernley averaging 25.4 and 24.3 ^{o}C. Conversely, winters are cold with mean annual January temperatures at Lahontan and Fernley averaging 0.4 and 0.5 ^{o}C. The growing season is 130-148 days, which is limited to springtime by freezing winter temperatures and summer drought.

The climax vegetation in this region is shadscale desert dominated by *Atriplex confertifolia, Sarcobatus baileyi, Artemisia spinescens,* and *Ephedra nevadensis* (Billings 1945). These widely-spaced, small, gray, upland shrubs contrast sharply with the forested and emergent wetland vegetation in floodplains, sinks, and at seeps.

METHODS

SOILS AND VEGETATION SAMPLING

County soil survey maps (Soil Conservation Service 1984) and field reconnaissance with Mr. Warren Archer, a Soil Conservation Service soil scientist, were used to select specific study sites that offered a variety of relatively undisturbed hydric soil types in close proximity to an upland soil



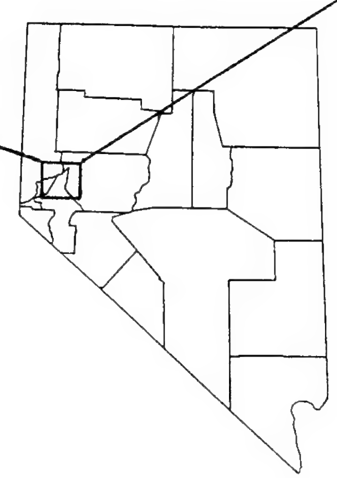


Figure 1. Map of northern Lyon County, Nevada, showing locations of the five study areas (□): Carson River 1 (CR1), Carson River @ Fort Churchill (CRFC), Carson River 3 (CR3), Fernley Wildlife Management Area (FWMA), and Fernley Marsh (FM).

Table 1. Names, longitude, latitude, land ownership, and soil types at five study areas in Lyon County, Nevada.

Site number	Study areas	Longitude latitude	Land ownership	Soil type
1	Carson River 1 (CR1)	119° 09' 42" 39° 19' 47"	Truckee- Carson Irrigation District	Dia, Dithod, Isolde, and Sagouspe
2	Carson River @ Fort Churcill (CRFC)	119° 16' 19" 39° 17' 20"	Nevada State Parks	Fallon-drained and Patna
3	Carson River 3 (CR3)	119° 10' 00" 39° 19' 34"	Truckee-Carson Irrigation District	Dia, Dithod, East Fork, Fallon, Isolde, and Sagouspe
4	Fernley Wildlife Management Area (FWMA)	119° 06' 35" 39° 35' 57"	Nevada Dept. of Wildlife and Truckee-Carson Irrigation District	Haplaquents, Medifibrists, Parran, Swingler, and Umberland
5	Fernley Marsh @ Interstate 80 (FM)	119° 06' 38" 39° 41' 23"	Bureau of Land Management and J & T, Inc.	Haplaquents, Medifibrists, Osobb, and Umberland

type. Soil boundaries were delineated and verified at each sample site by Mr. Archer. Vegetation sampling was conducted primarily between 18 May and 9 July; however, some additional sampling was conducted in late September 1987. At each study site, five 100 m^2 plots (quadrats) were randomly placed on each soil type present for sampling vegetation. Within each 100 m^2 plot, all trees (diameter at breast height [dbh] greater than 7.5 cm) were sampled by measuring individual dbh. A 4 m^2 subquadrat was nested in a randomly selected corner of the 100 m^2 quadrat within which shrubs were sampled. All tall shrubs (greater than 1.3 m tall and less than 7.5 cm dbh) were sampled by counting the number of main leaders, and all short shrubs (0.5 to 1.3 m tall) were sampled by counting individuals. Two 0.5 m^2 subquadrats also were placed randomly within the 100 m^2 quadrat in which all herbaceous taxa and all woody individuals less than 0.5 m tall were sampled by estimating their percent cover in six Daubenmire classes (Daubenmire 1968).

In addition, all species within the homogeneous area encompassing the 100 m^2 quadrat were listed, and estimates of species cover and abundance using standard Braun-Blanquet methodologies were made (Mueller-Dombois and

Ellenberg 1974). The two steps involved in this procedure included 1) gaining an initial familiarity with the general quantitative relations of all species present, (which was accomplished during sampling of tree and shrub strata, and while estimating Daubenmire cover classes of the ground cover stratum in the subquadrats,) and 2) assigning Braun-Blanquet cover and abundance ratings to each species present while standing in a central location from which the entire plant assemblage of the homogeneous area was easily overviewed.

Diagrammatic maps of each study area showing specific sampling sites are provided in Appendix A. Voucher plant specimens were collected and are deposited in the University of Nevada, Reno (RENO) herbarium.

To obtain information on environmental parameters that may be correlated to the vegetation, several selected parameters were measured while sampling the vegetation. The environmental data collected at each sampling site included elevation, aspect, slope, topographic position, soil moisture status, depth to water table, and distance to nearest surface water. The soil moisture status was expressed as the following eight-category subjective scale modified from Komárková (1979): (1) xeric, well-drained slopes; (2) subxeric, more or less well-drained slopes; (3) mesic, shallow depressions; (4) mesic-subhygric, temporary moisture; (5) subhygric, longer supply of moisture; (6) hygric, permanent supply of moisture; (7) subhydric standing water but occasionally dry; and (8) hydric, standing water.

DATA ANALYSIS

Importance values and ecological indicator values for each species were used to calculate weighted averages with the Wentworth and Johnson (1986) algorithm:

$$W_j = \left(\sum_{i=1}^{p} I_{ij} E_i \right) / \left(\sum_{i=1}^{p} I_{ij} \right)$$

where W_j = weighted average for stand j

I_{ij} = importance value for species i in stand j

E_i = ecological indicator value for species i

p = number of species in stand j

Weighted averages were calculated by stratum and for all strata combined. The importance value used for the shrub stratum was density, while the importance value used for the ground cover stratum was the combined Daubenmire cover for the two subquadrats. The importance value used for

weighted averages for the combined strata was the Braun-Blanquet cover-abundance class for each species present. This importance value was chosen for these analyses because it was the only value obtained for all species present regardless of strata. The ecological indicator value for each species was the value assigned by Reed (1986b), indicating its frequency of occurrence in wetlands. A provisional indicator value was assigned to all unlisted taxa encountered in this study (Appendix B).

Presence/absence averages were calculated with the same algorithm by assigning an importance value of 1.0 for all species present. Weighted averages and presence/absence averages less than 3.0 provisionally delineate wetland vegetation.

Weighted averages and presence/absence averages were compared by soil type using analysis of variance (ANOVA) and Tukey's multiple comparison test provided in the SPSS program (Nie *et al.* 1975).

RESULTS

Fourteen soils were identified at the five study areas and are described in Appendix C. Three of these soils, Dithod, Fallon, and Umberland, are included on the current list of hydric soils of Nevada (Soil Conservation Service 1985). Two soils, the Typic Haplaquents and Terric Medifibrists, have been described recently for the ongoing Churchill County soil survey (Soil Conservation Service, in preparation). The Typic Haplaquents and Terric Medifibrists will not receive series designations in the county survey because they are of very limited extent. However, these soils qualify for hydric status by the criteria outlined in the list of hydric soils (W. Archer, pers. comm.). Another four soils, Dia, East Fork, Parran, and Sagouspe are not included on the list of hydric soils, either because under natural conditions the known flooding durations are too short or the known depths to the water table are too great. Although these four soils are not considered hydric, at our study sites they have characteristics associated with wetness (W. Archer, pers. comm.). Independent observations and measurements of flooding duration and depths to the water table taken during the course of this study indicate that the Dia, East Fork, Parran, and Sagouspe soils actually meet the criteria for hydric status. Therefore, we term them hydriclike. Finally, five upland soils, a drained-phase of Fallon, Isolde, Osobb, Patna, and Swingler, are classified as nonhydric.

Interpretations of the results from this study are based on the following two assumptions: (1) the Typic Haplaquents and Terric Medifibrists are recently described hydric soils in this region and will be added to the list of hydric soils of Nevada when the Churchill County soil survey is completed; and (2) the Dia, East Fork, Parran, and Sagouspe soils, having characteristics associated with wetness at our study sites, are considered as a third category of soils termed hydriclike.

One hundred sixty-three plant taxa were identified in this study (Appendix B). Eighty-seven percent (142 taxa) were identified at the riparian wetland sites along the Carson River, while 42 taxa were identified from the emergent wetland sites in the Fernley area. The hydric and hydriclike soils along the Carson River had an average 53 plant taxa and were relatively species rich. However, the hydric and hydriclike soils associated with the emergent wetlands near Fernley had an average 16 plant taxa and were relatively species poor. The nonhydric soils at all study areas had an average of 11 plant taxa. Frequencies of occurrence of all species on the 14 different soil types are given in Appendix D.

Two trees and 20 shrubs were identified in this study. *Populus fremontii* and *Salix lasiandra* were sampled infrequently on the Carson River floodplain, and a few species of tall shrubs were sampled very infrequently on a few soil types. Trees and shrubs are dispersed in these study areas; however, they may have been undersampled because of the combination of an inadequate plot size and the random placement of those plots throughout a given soil type. Therefore, I was unable to perform statistical analyses on data from the tree and tall shrub strata. Statistical analyses were performed on limited data from the short shrub stratum for a few soil types at three study areas. The majority of the plant taxa identified were herbaceous annuals and perennials or small woody perennials, and allowed me to perform statistical analyses on data from the ground cover stratum at all study sites and on all soil types.

Descriptive statistics (means, standard errors, 95% confidence intervals) and the results of Tukey's multiple comparison tests for Daubenmire weighted averages and presence/absence averages for the short shrub stratum at the Fort Churchill and Fernley sites are given in Tables 2 and 3. Mean values of weighted and presence/absence averages for the short shrub stratum indicated that the vegetation classifies as wetland on the Umberland hydric soil type (mean = 2.8) and upland on the nonhydric soil types (means > 4.35). ANOVA indicated that there were significant differences at the $P < 0.05$ level among the means of weighted and presence/absence averages between hydric and nonhydric soil types, and results from the Tukey's tests clarified these differences.

Descriptive statistics for Daubenmire weighted averages and presence/absence averages for the ground cover stratum by site location are presented in Tables 4 and 5. These analyses indicated that some degree of variability in the calculated means was observed between sites for a given soil type. For example, along the Carson River, the hydriclike Dia soil type supported wetland vegetation with calculated weighted averages varying between 1.9 and 2.5.

Descriptive statistics and the results of Tukey's multiple comparison tests for Daubenmire weighted averages and presence/absence averages for the ground cover stratum are presented in Tables 6 and 7. Mean values of weighted averages and presence/absence averages for the ground cover stratum indicated that both hydric and hydriclike soils support wetland vegetation. However, mean values ≤ 3.0 for the two nonhydric soils at Fort Churchill (the drained-phase of Fallon and Patna) suggest that these soils support

Table 2. Descriptive statistics and results of Tukey's multiple comparison test for weighted averages of the short shrub stratum by soil type at Fort Churchill, Fernley Wildlife Management Area, and Fernley Marsh.

Soil type[1]	Number of plots sampled	Number of observ.	Mean	Standard error	95% confidence interval for mean	Tukey's range test[2]
Umberland	11	6	2.83	0.17	± 0.43	A
Fallon - drained	5	3	4.00	0.0	± 0.0	B
Swingler	5	5	4.35	0.31	± 0.86	B
Osobb	5	5	4.90	0.10	± 0.28	B
Patna	5	1	5.00	0.0	± 0.0	B

[1] Hydric soils are in bold print.
[2] Different letters denote groups significantly different at the 0.05 level.

Table 3. Descriptive statistics and results of Tukey's multiple comparison test for presence/absence averages of the short shrub stratum by soil type at Fort Churchill, Fernley Wildlife Management Area, and Fernley Marsh.

Soil type[1]	Number of plots sampled	Number of observ.	Mean	Standard error	95% confidence interval for mean	Tukey's range test[2]
Umberland	11	6	2.83	0.17	± 0.43	A
Fallon - drained	5	3	4.00	0.0	± 0.0	B
Swingler	5	5	4.47	0.23	± 0.63	B
Osobb	5	5	4.87	0.13	± 0.38	B
Patna	5	1	5.00	0.0	± 0.0	B

[1] Hydric soils are in bold print.
[2] Different letters denote groups significantly different at the 0.05 level.

Table 4. Descriptive statistics for weighted averages of the ground cover stratum by site location for each soil type.[1]

Soil type and site location[2]	Number of plots sampled	Number of observ.	Mean	Standard error	95% confidence interval for mean
East Fork					
Carson River 3	6	6	1.11	0.06	± 0.28
Medifibrists					
Fernley WMA	10	10	1.04	0.04	± 0.10
Fernley Marsh	10	10	1.32	0.07	± 0.21
Haplaquents					
Fernley WMA	10	10	1.25	0.16	± 0.44
Fernley Marsh	10	10	1.59	0.15	± 0.43
Sagouspe					
Carson River 1	10	10	1.60	0.22	± 0.60
Carson River 3	14	14	1.55	0.10	± 0.24
Carson River 6	10	10	1.40	0.16	± 0.44
Umberland					
Fernley WMA	12	12	1.66	0.12	± 0.32
Fernley Marsh	10	10	1.95	0.12	± 0.34
Fallon					
Carson River 3	10	10	1.96	0.11	± 0.32
Parran					
Fernley WMA	8	8	2.04	0.04	± 0.13
Dia					
Carson River 1	10	10	2.53	0.15	± 0.43
Carson River 3	10	10	1.90	0.15	± 0.41
Carson River 6	10	10	2.35	0.08	± 0.24
Dithod					
Carson River 1	12	12	2.33	0.13	± 0.34
Carson River 3	12	12	2.32	0.37	± 0.97
Carson River 6	10	10	2.70	0.13	± 0.36
Fallon-drained					
Fort Churchill	10	7	2.92	0.34	± 1.10
Patna					
Fort Churchill	10	5	3.00	0.0	± 0.0

Table 4. (Concluded)

Soil type and site location[1]	Number of plots sampled	Number of observ.	Mean	Standard error	95% confidence interval for mean
Isolde					
Carson River 1	10	4	5.00	0.0	± 0.0
Carson River 3	10	8	5.00	0.0	± 0.0
Carson River 6	10	7	4.90	0.10	± 0.43
Swingler					
Fernley WMA	10	7	5.00	0.0	± 0.0
Osobb					
Fernley Marsh	10	6	5.00	0.0	± 0.0

1 The statistics in this Table, and in Tables 5, 6, and 7, were computed after pooling pairs of small (0.5 m^2) subquadrats within each large (100 m^2) plot.
2 Hydric soils are in bold print.

Table 5. Descriptive statistics for presence/absence averages of the ground cover stratum by site location for each soil type.

Soil type and site location[1]	Number of plots sampled	Number of observ.	Mean	Standard error	95% confidence interval for mean
East Fork					
Carson River 3	6	6	1.14	0.07	± 0.30
Medifibrists					
Fernley WMA	10	10	1.08	0.08	± 0.22
Fernley Marsh	10	10	1.36	0.03	± 0.10
Haplaquents					
Fernley WMA	10	10	1.20	0.15	± 0.42
Fernley Marsh	10	10	1.54	0.14	± 0.40
Sagouspe					
Carson River 1	10	10	1.67	0.18	± 0.50
Carson River 3	14	14	1.64	0.12	± 0.29
Carson River 6	10	10	1.47	0.15	± 0.42

Table 5. (Concluded)

Soil type and site location[1]	Number of plots sampled	Number of observ.	Mean	Standard error	95% confidence interval for mean
Umberland					
Fernley WMA	12	12	1.72	0.10	± 0.26
Fernley Marsh	10	10	1.98	0.11	± 0.31
Parran					
Fernley WMA	8	8	1.88	0.13	± 0.40
Fallon					
Carson River 3	10	10	2.20	0.14	± 0.39
Dia					
Carson River 1	10	10	2.42	0.15	± 0.41
Carson River 3	10	10	1.97	0.11	± 0.73
Carson River 6	10	10	2.48	0.07	± 0.20
Dithod					
Carson River 1	12	12	2.17	0.11	± 0.27
Carson River 3	12	12	2.22	0.28	± 0.73
Carson River 6	10	10	2.69	0.14	± 0.39
Fallon-drained					
Fort Churchill	10	7	2.88	0.31	± 1.01
Patna					
Fort Churchill	10	5	3.00	0.0	± 0.0
Isolde					
Carson River 1	10	4	5.00	0.0	± 0.0
Carson River 3	10	8	5.00	0.0	± 0.0
Carson River 6	10	7	4.93	0.07	± 0.29
Swingler					
Fernley WMA	10	7	5.00	0.0	± 0.0
Osobb					
Fernley Marsh	10	6	5.00	0.0	± 0.0

[1] Hydric soils are in bold print.

Table 6. Descriptive statistics and results of Tukey's multiple comparison test for weighted averages of the ground cover stratum by soil type.

Soil type[1]	Number of plots sampled	Number of observ.	Mean	Standard error	95% confidence interval for mean	Tukey's range test[2]
East Fork	6	6	1.11	0.06	± 0.28	A
Medifibrists	20	20	1.18	0.06	± 0.14	A
Haplaquents	20	20	1.42	0.12	± 0.27	A B
Sagouspe	34	34	1.53	0.08	± 0.18	A B
Umberland	22	22	1.78	0.10	± 0.22	B
Fallon	10	10	1.96	0.11	± 0.32	B C D
Parran	8	8	2.04	0.04	± 0.13	B C D E
Dia	30	30	2.34	0.11	± 0.24	C D E
Dithod	34	34	2.44	0.14	± 0.31	D E
Fallon-drained	10	7	2.92	0.34	± 1.10	E
Patna	10	5	3.00	0.0	± 0.0	E
Isolde	30	19	4.98	0.02	± 0.04	F
Swingler	10	7	5.00	0.0	± 0.0	F
Osobb	10	6	5.00	0.0	± 0.0	F

[1] Hydric soils are in bold print.
[2] Different letters denote groups significantly different at the 0.05 level.

Table 7. Descriptive statistics and results of Tukey's multiple comparison test for presence/absence averages of the ground cover stratum by soil type.

Soil type[1]	Number of plots sampled	Number of observ.	Mean	Standard error	95% confidence interval for mean	Tukey's range test[2]
East Fork	6	6	1.14	0.07	± 0.30	A
Medifibrists	20	20	1.22	0.06	± 0.14	A
Haplaquents	20	20	1.37	1.11	± 0.26	A B
Sagouspe	34	34	1.60	0.08	± 0.17	A B
Umberland	22	22	1.84	0.08	± 0.18	B C
Parran	8	8	1.88	0.13	± 0.40	B C D
Fallon	10	10	2.20	0.14	± 0.39	C D E
Dia	30	30	2.29	0.09	± 0.19	D E
Dithod	34	34	2.34	0.12	± 0.26	D E F
Fallon-drained	10	7	2.88	0.31	± 1.01	E F
Patna	10	5	3.00	0.0	± 0.0	F
Isolde	30	19	4.98	0.02	± 0.04	G
Swingler	10	7	5.00	0.0	± 0.0	G
Osobb	10	6	5.00	0.0	± 0.0	G

[1] Hydric soils are in bold print.
[2] Different letters denote groups significantly different at the 0.05 level.

wetland vegetation also. ANOVA indicated significant differences among weighted averages and presence/absence averages between the different soil types. The results of Tukey's multiple comparison tests showed that slightly different groupings of soil types occurred between the weighted and presence/absence averaging methods. Neither averaging method was able to significantly separate hydric soils from hydriclike soils nor some hydric and hydriclike soils from some nonhydric soils. Weighted (and presence/absence) averages for the ground cover stratum alone were unable to statistically separate the hydric Dithod (and Fallon) soils from the hydriclike Dia and Parran soils nor from the nonhydric drained-phase of Fallon and Patna.

The data were analyzed by soil type for all species present (trees, shrubs, and ground cover species) without regard to strata using Braun-Blanquet cover-abundance classes as importance values. Descriptive statistics and the results of Tukey's multiple comparison tests for weighted averages and presence/absence averages are presented in Tables 8 and 9. Again, tests were unable to significantly separate hydric from hydriclike soils. However, except for the inability to separate Fallon from its nonhydric drained-phase, these averaging methods found significant differences between hydric/hydriclike soils and nonhydric soils when all species were taken into consideration. Furthermore, the averages indicated that hydric and hydriclike soils support wetland vegetation (means ≤ 2.87) and nonhydric soils support upland vegetation (means ≥ 3.27).

Data on the soil moisture status and depths to the water table were analyzed by soil type using ANOVA also. Descriptive statistics and the results of Tukey's multiple comparison tests for these two independent measures of wetness are given in Tables 10 and 11. The hydriclike soils had soil moisture status and depth to water table means that fell within the range of means for the hydric soils. The drained-phase of Fallon was the only nonhydric soil with a soil moisture status that was not significantly different from hydric and hydriclike soil types. Because depth to the water table revealed different significance groupings within the hydric and hydriclike soils than did the soil moisture status, the subjective soil moisture categories may not be good reflectors of actual water table depths.

DISCUSSION

Wetlands compose about 2% of the total vegetation in the intermountain region (Office of Technology Assessment 1984). Their small extent may be one reason for the paucity of known literature on wetland ecosystems in this arid region. No quantitative soil-vegetation correlation studies are known to have been conducted in any of western Nevada's wetlands prior to the present study.

The hydric soils (Dithod, Fallon, Terric Medifibrists, Typic Haplaquents, and Umberland) supported only wetland vegetation as defined by weighted or presence/absence averages less than 3.0. The hydriclike soils (Dia, East Fork, Parran, and Sagouspe) also supported only wetland vegetation

Table 8. Descriptive statistics and results of Tukey's multiple comparison test for weighted averages using Braun-Blanquet cover-abundance classes for all species present by soil type. The number of plots sampled are equivalent to the number of statistical observations.

Soil type[1]	Number of observations	Mean	Standard error	95% confidence interval for mean	Tukey's range test[2]
Medifibrists	10	1.28	0.08	± 0.19	A
East Fork	3	1.45	0.02	± 0.07	A B
Haplaquents	10	1.65	0.06	± 0.13	A B
Sagouspe	17	1.83	0.07	± 0.25	A B
Parran	4	1.95	0.30	± 0.94	A B C
Umberland	11	2.02	0.15	± 0.33	B C
Dia	15	2.34	0.10	± 0.23	C D
Dithod	17	2.38	0.10	± 0.22	C D
Fallon	5	2.87	0.13	± 0.36	D E
Fallon-drained	5	3.36	0.19	± 0.52	E F
Patna	5	3.96	0.27	± 0.76	G
Swingler	5	4.55	0.13	± 0.36	G
Isolde	15	4.57	0.08	± 0.16	G
Osobb	5	4.69	0.31	± 0.87	G

1 Hydric soils are in bold print.
2 Different letters denote groups significantly different at the 0.05 level.

Table 9. Descriptive statistics and results of Tukey's multiple comparison test for presence/absence averages using Braun-Blanquent cover-abundance classes for all species present by soil type. The number of plots sampled are equivalent to the number of statistical observations.

Soil type[1]	Number of observations	Mean	Standard error	95% confidence interval for mean	Tukey's range test[2]
East Fork	3	1.29	0.06	± 0.25	A
Medifibrists	10	1.32	0.08	± 0.19	A
Haplaquents	10	1.64	0.04	± 0.10	A B
Sagouspe	17	1.73	0.06	± 0.14	A B
Parran	4	1.90	0.20	± 0.63	A B C
Umberland	11	2.14	0.18	± 0.40	B C
Dia	15	2.30	0.10	± 0.22	C
Dithod	17	2.31	0.08	± 0.17	C
Fallon	5	2.72	0.07	± 0.21	C D
Fallon-drained	5	3.27	0.22	± 0.61	D E
Patna	5	4.03	0.27	± 0.75	E F
Swingler	5	4.18	0.24	± 0.65	F G
Isolde	15	4.60	0.06	± 0.13	F G
Osobb	5	4.87	0.13	± 0.38	G

1 Hydric soils are in bold print.
2 Different letters denote groups significantly different at the 0.05 level.

Table 10. Descriptive statistics and results of Tukey's multiple comparison test for depths to water table (in cm) for five hydric soils and four hydriclike soils.

Soil type[1]	Number of plots sampled	Number of observ.	Mean	Standard error	95% confidence interval for mean	Tukey's range test[2]
East Fork	3	3	3.33	3.33	± 14.35	A
Medifibrists	10	10	4.11	2.73	± 6.30	A
Haplaquents	10	10	10.60	3.08	± 6.97	A
Sagouspe	17	12	30.96	8.57	± 18.87	A B
Dia	15	10	48.70	7.45	± 16.84	B C
Umberland	11	11	53.11	8.17	± 18.84	B C
Fallon	5	5	60.60	7.13	± 19.80	B C
Dithod	17	12	60.91	6.25	± 13.93	C
Parran	4	4	76.33	2.67	± 11.47	C

1 Hydric soils are in bold print.
2 Different letters denote groups significantly different at the 0.05 level.

Table 11. Descriptive statistics and results of Tukey's multiple comparison test for subjective soil moisture status of each soil type.

Soil type[1]	Number of plots sampled	Number of observ.	Mean	Standard error	95% confidence interval for mean	Tukey's range test[2]
Medifibrists	10	10	7.90	0.10	± 0.23	A
Haplaquents	10	10	7.80	0.13	± 0.30	A
East Fork	3	3	7.50	0.50	± 2.15	B
Parran	4	4	7.00	0.0	± 0.0	B
Umberland	11	11	6.91	0.09	± 0.20	B
Sagouspe	17	12	5.92	0.46	± 1.01	B
Dia	15	10	4.20	0.49	± 1.16	C
Dithod	17	12	4.00	0.44	± 0.98	C
Fallon	5	5	4.00	0.0	± 0.0	C
Fallon-drained	5	5	2.50	0.0	± 0.0	C D
Patna	5	5	1.00	0.0	± 0.0	D
Swingler	5	5	1.00	0.0	± 0.0	D
Isolde	15	10	1.00	0.0	± 0.0	D
Osobb	5	5	1.00	0.0	± 0.0	D

1 Hydric soils are in bold print.
2 Different letters denote groups significantly different at the 0.05 level.

by this same criterion. Tests using weighted averages or presence/absence averages to determine whether the vegetation was wetland and tests of independent measures of soil moisture were unable to statistically discriminate the hydriclike soils from hydric soils. The Dia, East Fork, and Sagouspe soils located on the Carson River floodplain actually averaged shallower depths to the water table than the two hydric soils present (27.7 cm for hydriclike soils and 60.7 cm for hydric soils). The Carson River floodplain is subject to annual inundation when Lahontan Reservoir reaches maximum storage capacity. The area is flooded or ponded an average 70 days yr^{-1} in springtime (U.S. Geological Survey 1986) and apparently has resulted in the floodplain soils acquiring characteristics associated with wetness and supporting wetland vegetation. Dia, Dithod, and Fallon soils tend to occur on the floodplain terraces or on the slopes of the river's natural levee. In contrast, East Fork and Sagouspe soils tend to occur in shallow depressions within the floodplain. Because the depressions are subject to longer periods of flooding than the terraces that they occur on, soils found in the depressions would tend to be wetter.

The Parran soil located in the Carson Desert near Fernley is not subject to the same annual inundation as the other hydriclike soils. Parran is a strongly salt-affected soil. The kinds of plants growing in Parran include *Distichlis spicata* var. *stricta*, *Allenrolfea occidentalis*, *Triglochin maritima*, and *Sarcobatus vermiculatus*. These species are extremely salt-tolerant, yet they are limited to moist habitats or areas with accessible ground water. All analyses indicated that the vegetation on Parran is wetland vegetation, with averages ranging between 1.88 for presence/absence averages to 2.04 for weighted averages for the ground cover stratum. The combination of a relatively moist soil, which tends to occur in topographic depressions, along with a high salt content, probably allows for the growth of these salt-tolerant wetland species. Additional sampling on other kinds of alkali wetlands, such as desert sink scrub, desert saltbush scrub, and alkali meadows, marshes, and seeps, would help to clarify this relationship.

Analyses that considered all species present in the sample area yielded somewhat better results than analyses using ground cover data only. This method has the advantage of incorporating the maximum amount of data by including the ecological indicator values for all species present. Weighted averages, which consider species importance, and presence/absence averages, which use only species presence, were equally effective in discriminating hydric and hydriclike soils from nonhydric soils. Wentworth and Johnson (1986) found these two methods equally effective also. Presence/absence averaging requires less field time because no measure of species importance is required; however, measures of species importance provides additional community information. Both methods require proper species identification and assignment of correct ecological indicator values. These findings suggest that perhaps the best methodology for delineating Nevada's wetlands involves estimating cover classes for all species present without regard to different strata and using the weighted averaging algorithm.

SAMPLE SIZE

An attempt was made to determine if adequate sampling was done for this study because field sampling methodologies did not strictly follow FWS guidelines. To estimate whether satisfactory sampling was performed, one may determine at what sample size additional quadrats do not significantly affect the mean of the more important species. This can be tested by calculating and plotting running means of a given parameter (Kershaw 1973).

Running means of cover classes for four species with high frequencies on different soil types along the Carson River are provided in Figure 2. These means were calculated from random samples of the quadrats, in this case, simply the order in which the plots were sampled. After an initial greater variation, the curves become less variable around the twentieth quadrat.

There is no strictly objective criterion to determine an adequate sample size. The size of a satisfactory sample is often subjectively set at five to ten percent of a more time-consuming maximum sample. For *Elymus triticoides* on Dithod soil and *Xanthium strumarium* on Sagouspe soil, a sample size between 20 and 25 quadrats falls within five percent of the sample mean of 34 quadrats. For *Juncus balticus* on Dia and *Oryzopsis hymenoides* on Isolde, a sample size between 15 and 20 quadrats falls within five percent of the sample mean of 30 quadrats.

The number of species sampled within the herbaceous subquadrats and the total number of species listed in the homogeneous area encompassing the 100 m^2 quadrats as the sample size increases are shown in Figure 3. On all four soil types, the number of species sampled (Figure 2) in the herbaceous subquadrats was about half to less than half the total number of species found in the larger homogeneous area. For hydric and hydriclike soil types, a sample size of 12 100-m^2 quadrats adequately sampled the area for species composition. A sample size about half this size adequately sampled the species composition of the less diverse nonhydric soil, Isolde. Perhaps species composition is best sampled by listing all species present within a homogeneous area since subquadrats used to sample vegetation in the lower strata did not adequately sample all species present.

Although a larger, more time-consuming sample size will not significantly change the mean of the parameter of interest (cover, number of species, etc.,) it will decrease the standard error. A comparison of the standard errors obtained with the sample size from this study and the standard errors obtained from Dick-Peddie *et al.* (1987), a similar study that followed FWS guidelines, indicates little difference in error terms. Along with the evidence from Figures 1 and 2, this suggests that a sufficient sample was obtained for the purposes of this study. Nevertheless, if time and money resources permit, a larger sample size is desirable and should be obtained.

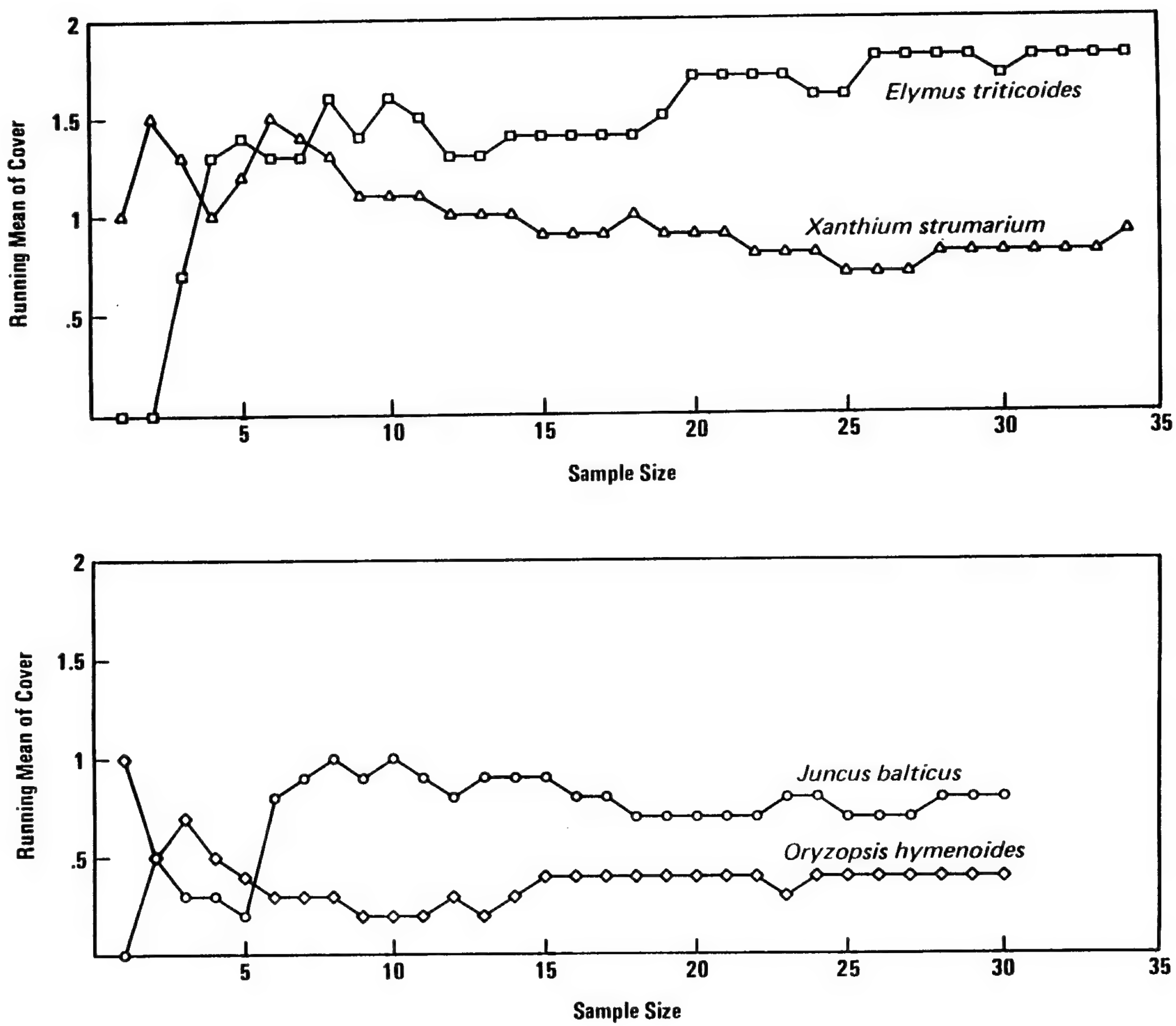


Figure 2. The running mean of cover classes with increasing sample size for four important species along the Carson River. Data are for Elymus triticoides on Dithod (□), Xanthium strumarium on Sagouspe (△), Juncus balticus on Dia (○), and Oryzopsis hymenoides on Isolde (◇).

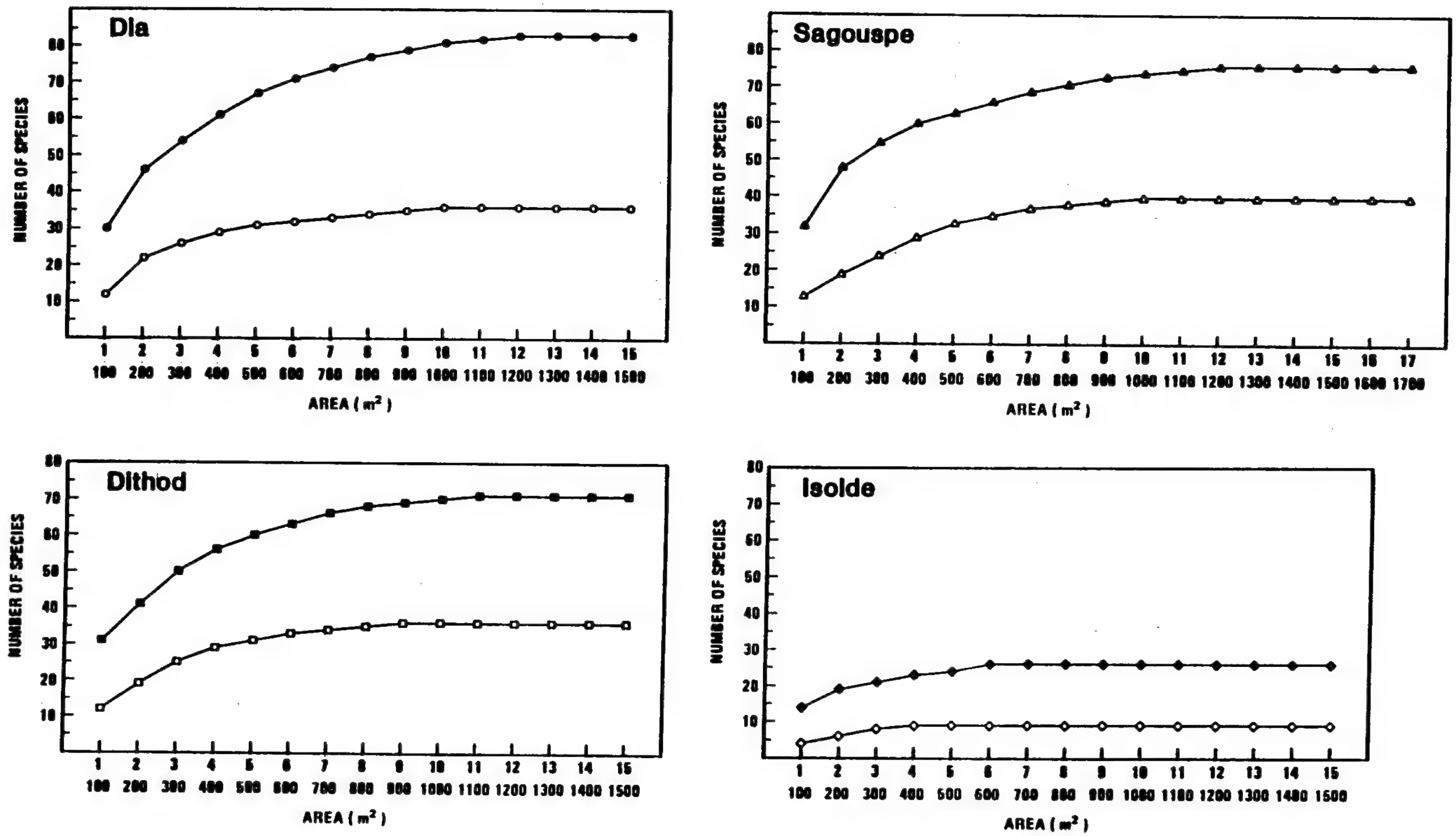


Figure 3. The number of species sampled within the herbaceous subquadrat (open symbols and upper area scale) and the total number of species listed for the 100-m^2 quadrats (closed symbols and lower area scale) with increasing sample size. Data are shown for four soil types: hydriclike Dia (●) and Sagouspe (▲); hydric Dithod (■); and nonhydric Isolde (◆).

CONCLUSIONS

Weighted averages and presence/absence averages of all species present proved effective in delineating hydric and hydriclike soil types from nonhydric soil types in wetlands in Nevada. However, these methods could not delineate hydric soils from hydriclike soils having characteristics associated with wetness. In the special hydrological situation encountered on the Carson River floodplain where nonhydric soils are artificially flooded on a regular basis, independent measures of wetness showed that some normally nonhydric soils are hydrologically like hydric soils. Consequently, wetland vegetation predominated on these soils.

The highly salt-affected hydriclike soil in emergent wetlands also supported wetland vegetation. Where high salinities reduce plant competition and ground water is relatively shallow, salt-tolerant wetland species are able to dominate. Further study of alkaline wetlands may show that highly saline, nonhydric, soils support wetland vegetation, or that a reexamination of the hydrological properties and a reclassification of these soils is needed.

In Nevada's riparian and emergent wetlands, wetland plants dominate vegetation associations on hydric and hydriclike soils. In general, the Wentworth and Johnson system proved effective for delineating wetlands within the Great Basin. The system yielded better results when all species present were considered rather than when data from only the ground cover stratum were used.

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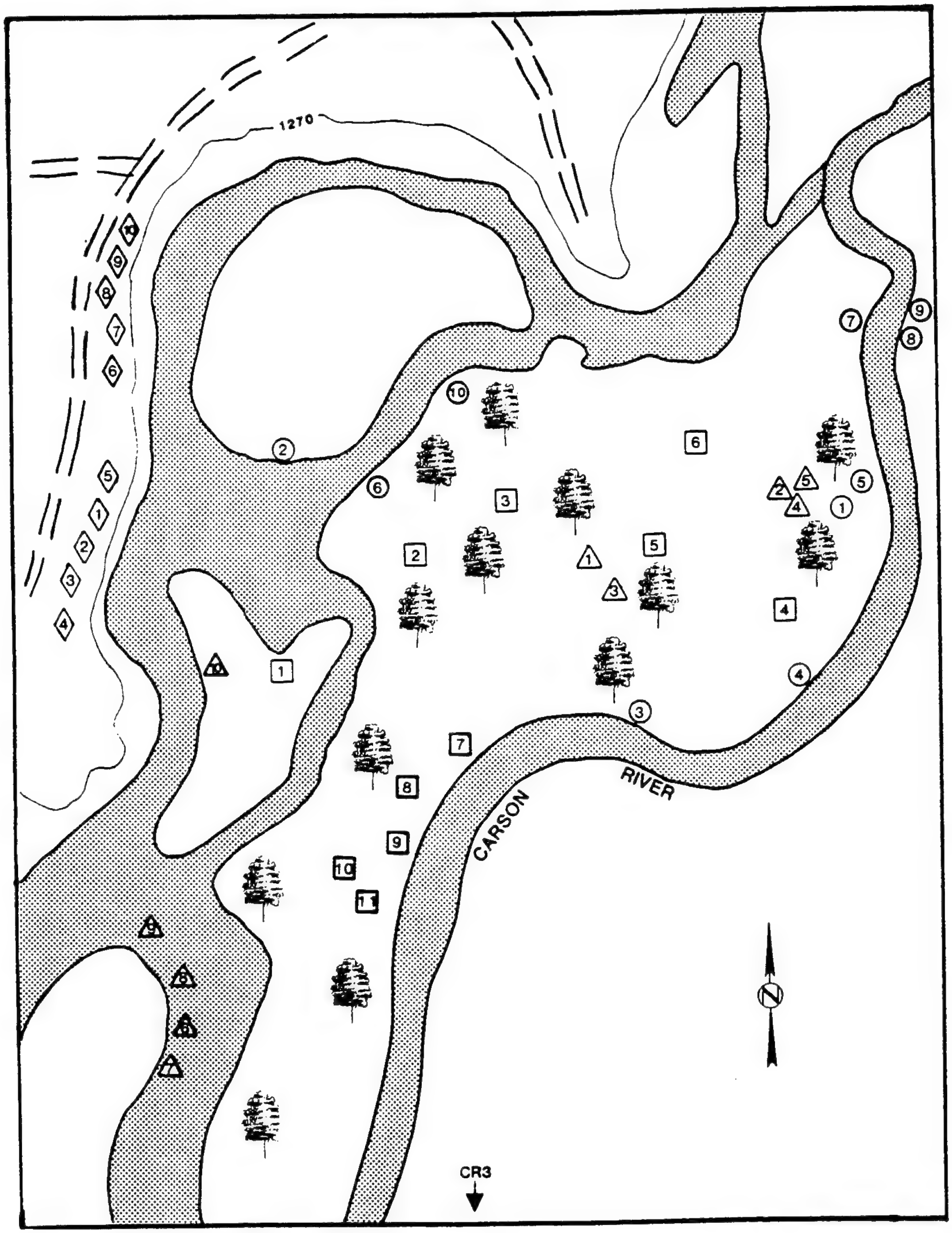
Appendix A

Diagrammatic maps of 3 study areas along the lower Carson River and 2 study areas near Fernley, Nevada.

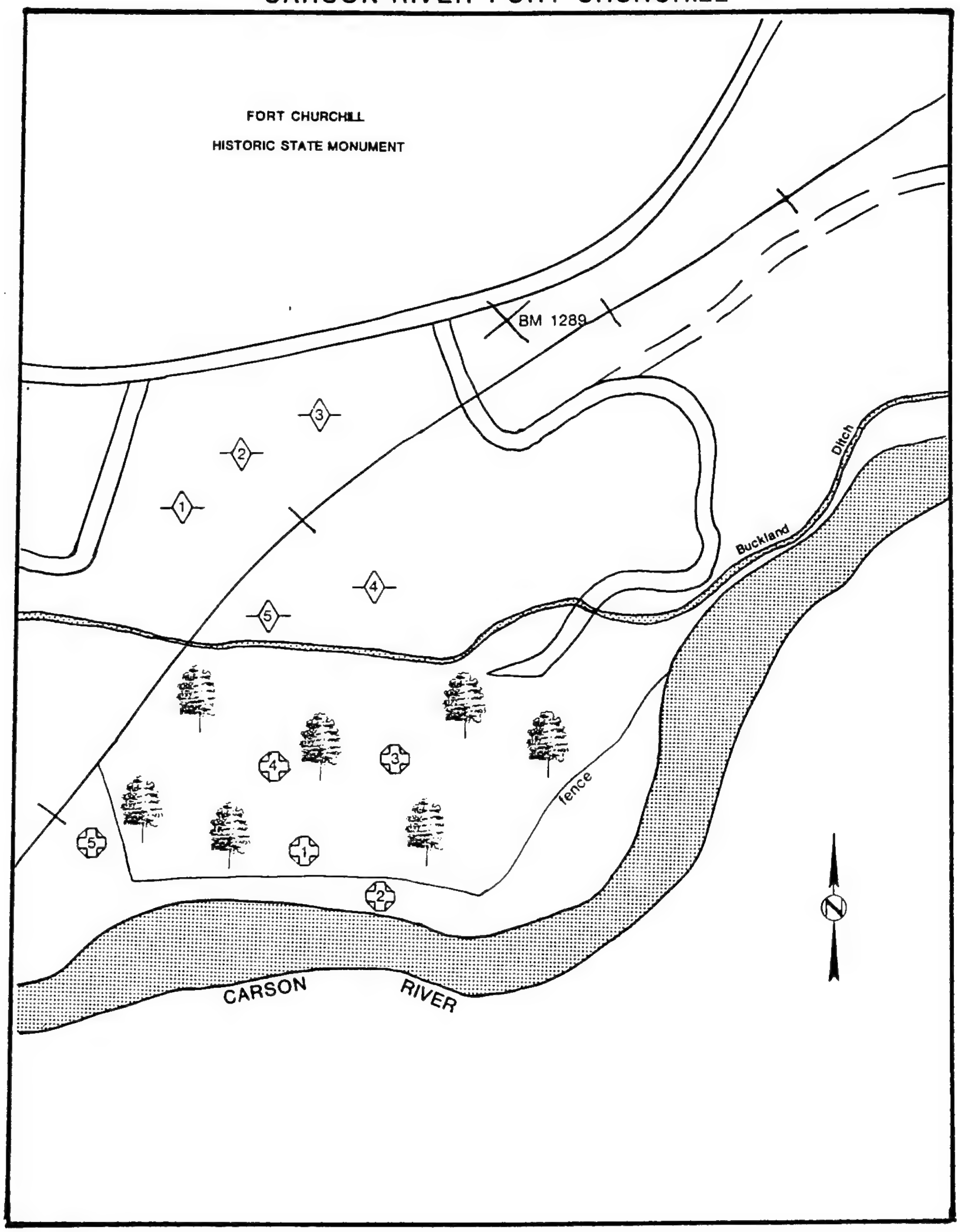
Legend

	DIA		POPULUS FREMONTII WOODLANDS
	DITHOD		MARSH
	EAST FORK		WATER
	FALLON		PAVED ROAD
	HAPLAQUENTS		DIRT ROAD
	MEDIFIBRISTS		RAILROAD
	PARRAN	—1270—	CONTOUR LINES
	SAGOUSPE	X BM	BENCH MARK
	UMBERLAND	TCID	TRUCKEE-CARSON IRRIGATION DISTRICT
		CR1	CARSON RIVER 1
	FALLON, DRAINED-PHASE	CR3	CARSON RIVER 3
	ISOLDE		
	OSOBB		
	PATNA		
	SWINGLER		

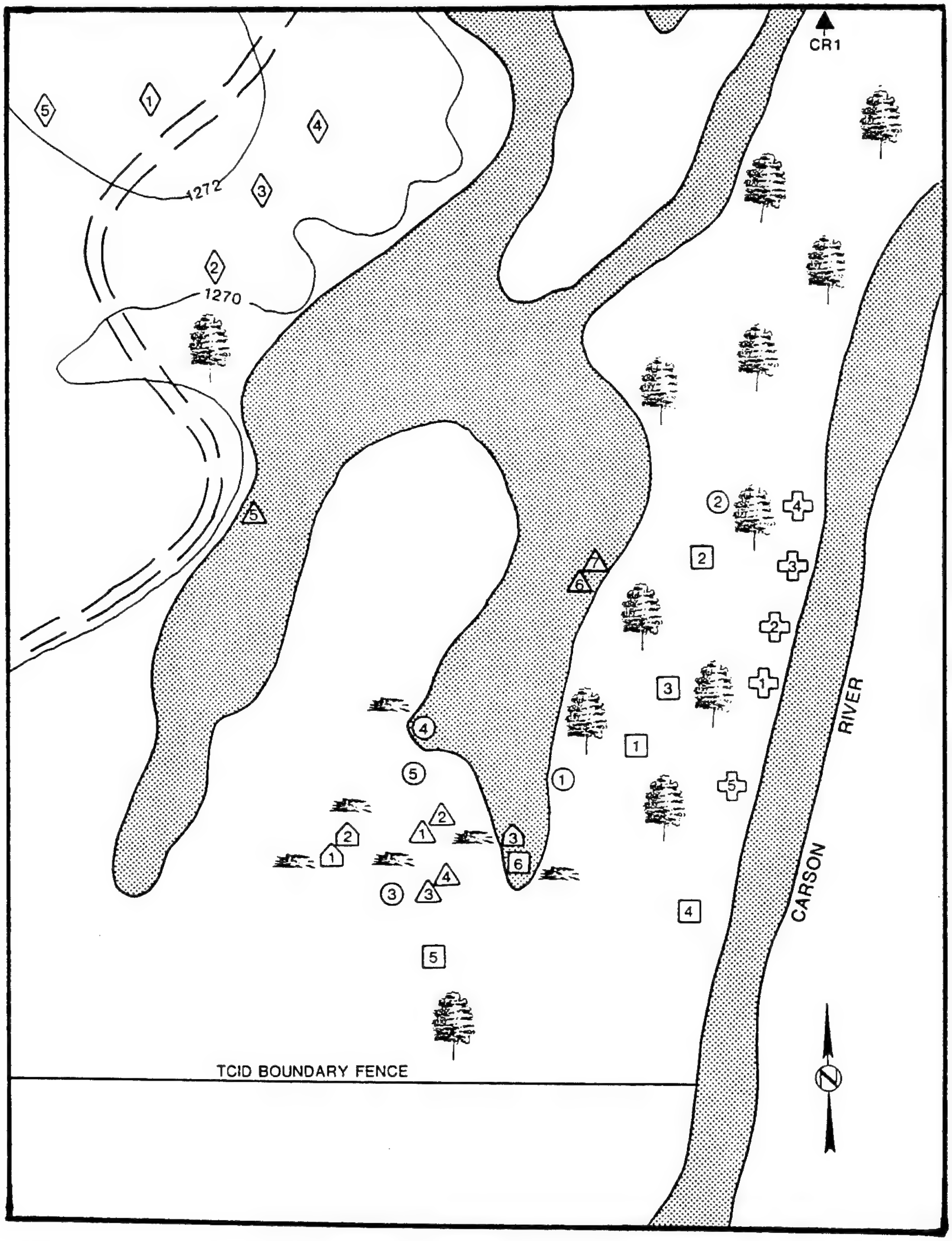
CARSON RIVER 1



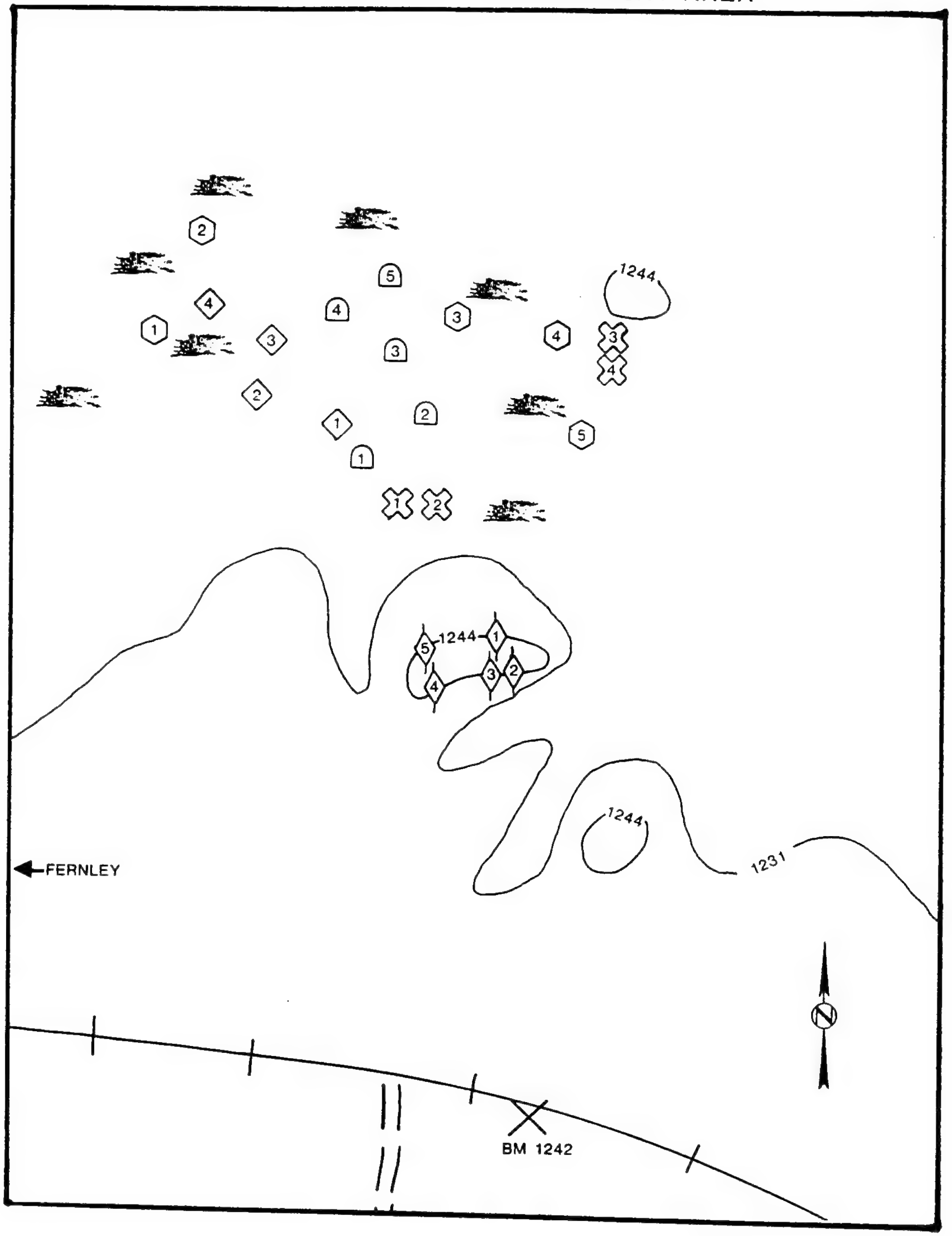
CARSON RIVER–FORT CHURCHILL



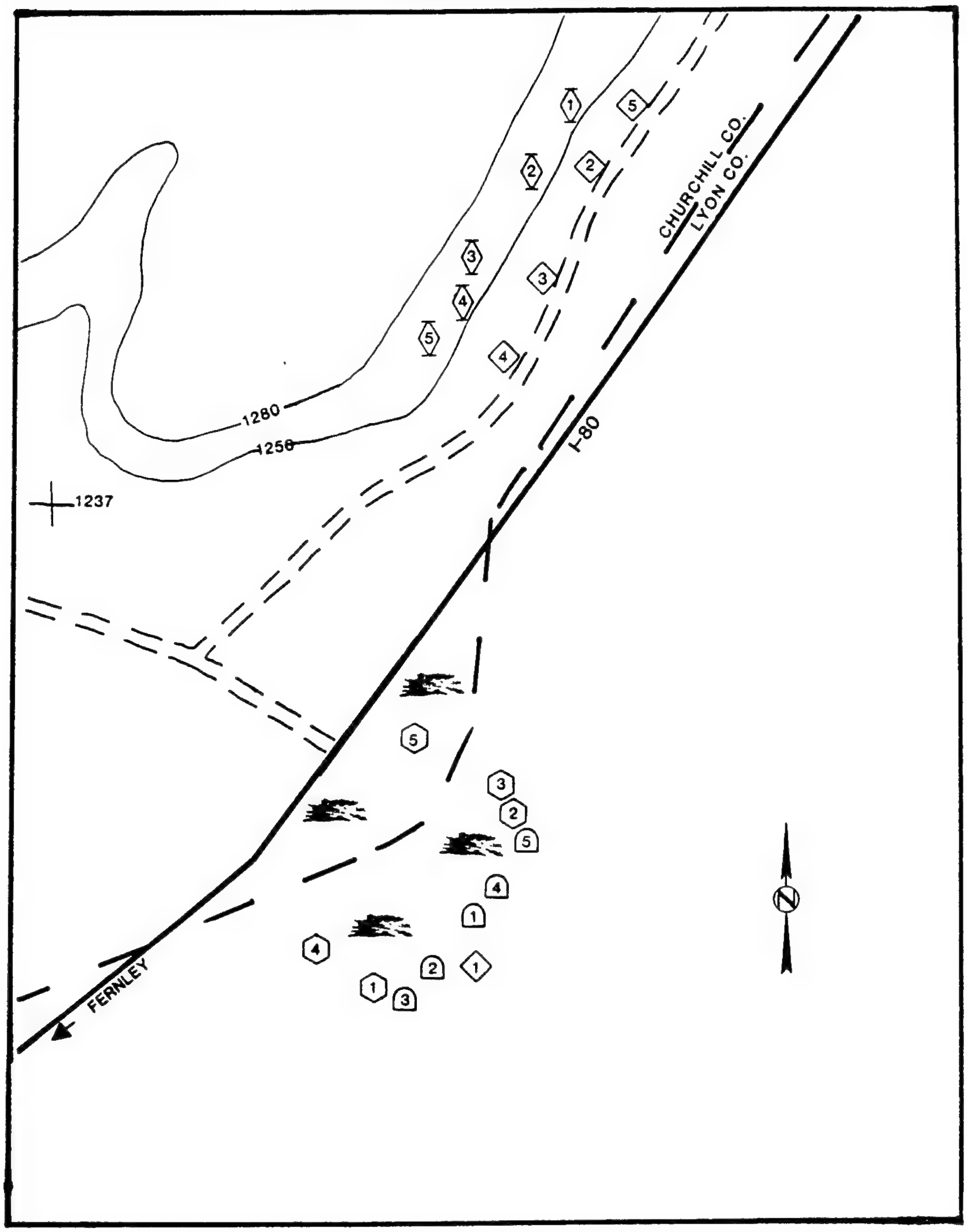
CARSON RIVER 3



FERNLEY WILDLIFE MANAGEMENT AREA



FERNLEY MARSH



Appendix B

Plant species names and their ecological indicator values from Reed (1986) for all plants identified in riparian wetlands along the lower Carson River and emergent wetlands in the Carson Desert. An ecological indicator value of one signifies an obligate wetland plant while a value of five signifies an upland plant. Asterisks indicate provisional indicator values which were determined by consultation with Mr. Arnold Tiehm of the New York Botanical Garden. These provisional indicator values were assigned based on the known frequency of occurrence in wetlands in this region.

Species	Ecological Indicator Value
Abronia turbinata	5
Agrostis stolonifera	2
Alisma plantago-aquatica	1
Allenrolfea occidentalis	2
Alopecurus aequalis	1
Alopecurus geniculatus	1
Amaranthus californicus	2
Ambrosia acanthicarpa	5
Arabis sp.	3*
Artemisia biennis	2
Artemisia ludoviciana	3*
Artemisia spinescens	5
Artemisia tridentata ssp. *tridentata*	4*
Artemisia tridentata ssp. *wyomingensis*	5
Asclepias fasciullaris	3
Aster frondosus	1
Aster sp.	3*
Atriplex canescens	5
Atriplex confertifolia	5
Atriplex patula	2
Atriplex sp.	2*
Atriplex torreyi	3
Azolla mexicana var. *canadense*	1
Bassia hyssopifolia	2
Beckmannia syzigachne	1
Berula erecta	1
Bidens cernua	1
Bromus carinatus	5
Bromus rubens	5
Bromus tectorum	5

Species	Ecological Indicator Value
Callitriche palustris	1*
Cardaria pubescens	3*
Carex athrostachya	1
Carex lanuginosa	1
Carex nebraskensis	1
Carex praticola	3
Carex rostrata	1
Carex sp.	1*
Centaurium exaltatum	2
Chenopodium album	4
Chenopodium botrys	4
Chenopodium rubrum	1
Chenopodium sp.	5*
Chrysothamnus nauseosus ssp. *consimilans*	5
Chrysothamnus nauseosus ssp. *hololeucus*	5
Chrysothamnus parryi	5
Cichorium intybus	5
Cirsium arvense	3
Cirsium sp.	5*
Cirsium vulgare	5
Cleomella obtusifolia	5
Conium maculatum	2
Conyza canadensis	2
Cordylanthus maritimus var. *canescens*	1
Crypsis alopecuroides	1
Cuscuta sp.	5*
Cyperus fuscus	1*
Cypselea humifusa	1*
Dalea polyadenia	5
Descurainia sophia	5
Distichlis spicata var. *stricta*	2
Echinochloa crusgalli	2
Echinodorus rostratus	1
Eleocharis palustris	1
Eleocharis parishii	2
Eleocharis pauciflora	1
Eleocharis rostellata	1
Elymus triticoides	3
Epilobium ciliatum var. *ciliatum*	3
Equisetum arvense	3
Eriogonum brachyanthum	5
Euphorbia ocellata	5
Gilia leptomeria var. *micromeria*	5
Gnaphalium microcephalum	4*
Gnaphalium palustre	2
Grayia spinosa	5
Halogeton glomeratus	5
Hordeum brachyantherum	2
Hordeum jubatum	2
Iva axillaris	2

Species	Ecological Indicator Value
Juncus balticus	1
Juncus bufonius	1
Juncus nevadensis	2
Kochia americana	3
Lactuca serriola	3
Lemna minor	1
Lepidium latifolium	4
Lepidium virginicum var. *pubescens*	4
Limosella aquatica	1
Lindernia dubia	1
Lotus tenuis	3*
Matricaria maritima	4*
Medicago hispida	3*
Medicago sativa	5
Melilotus albus	4
Mentha arvensis	2
Muhlenbergia asperfolia	2
Oenothera flava	2
Oryzopsis hymenoides	5
Paspalum distichum	2
Pectis papposa	5
Phacelia bicolor	5
Plagiobothrys scouleri	1
Plagiobothrys stipitatus var. *micranthus*	1
Plantago major var. *pachyphylla*	3
Poa juncifolia	3
Poa pratensis	3
Poa sp.	3*
Polygonum amphibium var. *stipulaceum*	1
Polygonum argyrocoleon	3
Polygonum coccinium	1*
Polygonum hydropiperoides	1
Polygonum lapathifolium	1
Polygonum persicaria	2
Polypogon monspeliensis	2
Populus fremontii	2
Potentilla rivalis var. *millegrana*	1
Puccinellia fasciculata	1
Ranunculus cymbalaria var. *saximontanus*	1
Ranunculus gmelinii	2
Ranunculus sceleratus var. *multifidus*	1
Rorippa curvisiliqua	1
Rorippa islandica var. *occidentalis*	2*
Rumex crispus	2
Rumex maritimus	2
Ruppia maritima	1
Sagittaria cuneata	1
Salix lasiandra	1
Salix sp.	1*
Salsola australis	5

Species	Ecological Indicator Value
Sarcobatus baileyi	5
Sarcobatus vermiculatus	3*
Scirpus acutus	1
Scirpus maritimus	1*
Shepherdia argentea	4*
Sida hederacea	4*
Sisymbrium altissimum	4
Solidago occidentalis	3*
Sonchus asper	4
Sparganium eurycarpum	1
Sphaeralcea ambigua	5
Sporobolus airoides	3
Stanleya pinnata	5
Tamarix pentandra	2
Tanacetum vulgare	5
Taraxacum officinale	4
Tetradymia canescens	5
Tetradymia glabrata	5
Tetradymiasp.	5*
Thlaspi arvense	5
Tiquilia nuttallii	5
Trifolium hybridum	3
Triglochin maritima	1
Typha domingensis	1
Typha latifolia	1
Verbascum thapsus	5
Verbena bracteata	4
Veronica anagallis-aquatica	1
Veronica peregrina var. *xalapensis*	2
Xanthium strumarium	3
Zannichellia palustris	1

Appendix C

Descriptions of Fourteen Soil Types

Dia: Fluvaquentic Haploxerolls, fine-loamy over sandy or sandy-skeletal, mixed, mesic. The Dia, flooded phase, consists of very deep poorly drained soils formed from mixed rocks on basin-fill plains. Slopes are 0-2 percent. Their profiles consist of three main parts: (1) grayish brown loam about 48 cm thick; (2) grayish brown silty clay loam and light brownish gray sandy loam about 13 cm thick; and (3) pale brown sand to 152 cm. Permeability is moderately slow to a depth of 48 cm and rapid below this depth. Available water capacity is moderate. Effective rooting depth is limited by a seasonal high water table that is at a depth of 30-61 cm from March through June. This soil is subject to flooding during prolonged, high-intensity storms. Mean annual air temperature is 10-13 ^{o}C. Mean annual precipitation is 10-20 cm.

Dithod: Fluvaquentic Haploxerolls, fine-loamy, mixed, mesic. The Dithod, moderately wet phase, consists of very deep, artificially inundated soils formed in alluvium from mixed parent rock on stream terraces and basin-fill plains. Slopes are 0-2 percent. Their profiles consist of three main parts: (1) grayish brown clay loam about 28 cm thick; (2) light brownish gray silt loam about 23 cm thick; and (3) stratified grayish brown loam, silt, sandy loam and loamy fine sand to 152 cm. Permeability is moderately slow. Available water capacity is high. Effective rooting depth is limited by a seasonal high water table that is at a depth of 46-107 cm from April through September. This soil is subject to flooding during prolonged, high-intensity storms. Mean annual air temperature is 10-11 ^{o}C. Mean annual precipitation is 10-15 cm.

East Fork: Fluvaquentic Haploxerolls, fine loamy, mixed, mesic. The East Fork, flooded phase, consists of deep somewhat poorly drained soils formed on recent valley flats from mixed alluvium. Slopes are 0-2 percent. Their profiles consist of two main parts: (1) grayish brown clay loam about 28 cm thick; and (2) stratified gray and light brownish gray loam to light silty clay to 152 cm. Permeability is moderately slow. Available water capacity is high. Effective rooting depth is limited by a seasonal high water table that is at a depth of 107-152 cm from May through June. This soil is subject to occasional, brief periods of flooding in April through June. Mean annual air temperature is 9-13 ^{o}C. mean annual precipitation is 10-20 cm.

Fallon: Aquic Xerofluvents, coarse-loamy, mixed, nonacid, mesic. The Fallon, flooded and drained phases, consists of deep, somewhat poorly drained soils formed in alluvium from mixed rock on low stream terraces and basin-

fill plains. Slopes are 0-2 percent. Their profiles consist of two main parts: (1) pale brown silt loam about 25 cm thick; and (2) light brownish gray and light gray mottled, stratified silt loam to sand to 152 cm. Permeability is moderate to very rapid. Available water capacity is low to moderate. Effective rooting depth is limited by a seasonal high water table that is at a depth of 91-152 cm from April through September. The flooded-phase is subject to frequent, brief periods of flooding in March through November. The **drained-phase of Fallon** is subject to flooding during prolonged, high-intensity storms. Mean annual air temperature is 10-13 ^{o}C. Mean annual precipitation is 10-20 cm.

Haplaquents: Typic Haplaquents, fine-montmorillonitic, mesic. The Haplaquents consist of deep, very poorly drained soils formed in lacustrine sediments derived from mixed parent bedrock on lake plains. Slopes are 0-2 percent. Their profiles consist of three main parts: (1) 0-10 cm of undecomposed mat of vegetation and fine roots; (2) olive gray silty clay with mottles becoming less distinct to 102 cm; and (3) olive gray silty clay with a few 1-2 cm strata of very fine sandy loam and common large prominent dark brown mottles. Mean annual air temperature is about 11 ^{o}C. Mean annual precipitation is about 13 cm.

Isolde: Typic Torripsamments, mixed, mesic. The Isolde consists of very deep, excessively drained soils that formed in eolian sand from mixed rock sources. Slopes are 0-30 percent. The surface is a light gray fine sand about 15 cm thick. The underlying material is a light gray fine sand extending to 152 cm. Permeability is very rapid. Available water capacity is low. Effective rooting depth is 152 cm or more. Mean annual air temperature is 10-12 ^{o}C. Mean annual precipitation is 10-18 cm.

Medifibrists: Terric Medifibrists, clayey, montmorillonitic, euic, mesic. The medifibrists consist of deep, very poorly drained soils consisting of a thick organic layer over lacustrine sediments on lake plains, associated with seeps. Slopes are 0-2 percent. The profile consists of: (1) 0-56 cm of undecomposed fibric materials; and (2) dark greenish gray to grayish brown silty clay loam with medium prominent mottles to 155 cm. Mean annual air temperature is about 11 ^{o}C. Mean annual precipitation is about 13 cm.

Osobb: Typic Durorthids, loamy-skeletal, mixed, mesic, shallow. The Osobb consists of very shallow and shallow well drained soils that formed in mixed volcanic residuum, on uplands. Slopes are 8-30 percent. The surface is a light brownish gray very cobbly very fine sandy loam about 10 cm thick. The upper underlying material is a very cobbly fine sandy loam about 33 cm thick. The lower underlying material is an indurated hardpan about 3 cm thick over bedrock. Permeability is moderately rapid. Available water capacity is 4-5 cm. Mean annual air temperature is 9-10 ^{o}C. Mean annual precipitation is 10-18 cm.

Parran: Typic Salorthids, fine, montmorillonitic, mesic. The Parran consists of very deep, somewhat poorly drained soils formed in clayey lacustrine materials derived from mixed rock sources on low lake terraces and in basins. Slopes are 0-2 percent. The surface is a light brownish gray silty clay about 13 cm thick. The upper part of the underlying material is a

light gray silty clay about 33 cm thick. The lower part of the underlying material is a light gray silty clay extending to 152 cm. Permeability is very slow. Available water capacity is about 19-23 cm. Mean annual air temperature is 11-13 ^{o}C. Mean annual precipitation is 10-15 cm.

Patna: Typic Haplargids, coarse-loamy, mixed, mesic. The Patna consists of very deep, somewhat excessively drained soils formed in sandy alluvium on lake terraces and dunes. Slopes are 0-2 percent. Their profile has 4 main parts: (1) light brownish gray sand 20 cm thick; (2) pale brown sandy loam 30 cm thick; (3) pale brown loamy sand 38 cm thick; and (4) light brownish gray gravelly coarse sand to 152 cm. Permeability is moderately rapid in the upper part of the profile and rapid in the lower part. Available water capacity is 10-13 cm. Mean annual air temperature is 10-12 ^{o}C. Mean annual precipitation is 10-15 cm.

Sagouspe: Aquic Xerofluvents, sandy, mixed, mesic. The Sagouspe, flooded phase, consists of deep, somewhat poorly drained soils formed in depressional areas on flood plains. Slopes are 0-2 percent. The profiles have two main parts: (1) light gray to pale brown loam about 41 cm thick; and (2) light brownish gray, loamy sand and sand finely stratified with sandy loam and loam to 152 cm. Permeability is rapid. Available water capacity is moderate. Effective rooting depth is limited by a seasonal high water table that is at a depth of 46-107 cm from March through June. The soil is subject to occasional, long periods of flooding in April through June. Mean annual air temperature is 10-13 ^{o}C. Mean annual precipitation is 10-15 cm.

Swingler: Typic Torriorthents, fine-silty, mixed (calcareous), mesic. The Swingler series consists of very deep, nearly level to gently sloping, moderately well-drained soils that formed a lacustrine sediment. Slopes are 0-4 percent. A representative profile has a layer of light brownish-gray sandy loam about 48 cm thick over light-gray silt loam extending to 152 cm. Permeability is moderately slow. Available water capacity is about 15-20 cm. Mean annual air temperature is 11-13 ^{o}C. Mean annual precipitation is 10-15 cm.

Umberland: Aeric Halaquepts, fine, montmorillonitic (calcareous), mesic. The Umberland, ponded phase, consists of very deep, somewhat poorly drained soils formed in lacustrine sediments on stream terraces. Slopes are 0-2 percent. The surface is light olive brown silty clay loam about 13 cm thick. The underlying material is light olive gray silty clay that extends to 152 cm. Mean annual air temperature is 8-10 ^{o}C. Mean annual precipitation is 15-20 cm.

Appendix D

Frequencies of occurrence of all species identified in this study on 14 different soil types. Frequencies were derived by dividing the number of quadrats in which a species was found by the total number of quadrats sampled on that soil type and multiplying by 100. Abbreviations of soil types are given at the end of the appendix. Soil types are ordered from most hydric to most xeric.

Species	Eas	Med	Hap	Sag	Par	Umb	Dia	Dit	Fal	Fdp	Pat	Swi	Iso	Oso
Alisma plantago-aquatica	100			53			7	12						
Crypsis alopecuroides	100			35			20							
Echinochloa crusgalli	100			65			13	6						
Eleocharis palustris	100			82			40	47	20					
Polygonum amphibium var. *stipulaceum*	100			94			27	29	40					
Sagittaria cuneata	100			53			13	6						
Salix lasiandra	100			53			47	35						
Scirpus acutus	100	70	40	65		46	7	6						
Alopecurus aequalis	67			76			33	29						
Typha latifolia	67			18			13	6	20					
Xanthium strumarium	67			88			93	53	100					
Azolla mexicana var. *canadense*	33			12			7	6						
Conium maculatum	33						20	18						
Cyperus fuscus	33			29				6						
Epilobium ciliatum var. *ciliatum*	33	10		41			33	35	80					
Paspalum distichum	33			12										
Polygonum lapathifolium	33			29			27							
Polypogon monspeliensis	33	10	60	65		55	53	24						
Rorippa islandica var. *occidentalis*	33			35			20	29						
Rumex crispus	33			71			87	65	100					
Sparganium eurycarpum	33			18				6						
Veronica anagallis -aquatica	33			47			20	18						
Distichlis spicata var. *stricta*		50	100		100	100	7	6		80			33	
Typha domingensis		30	30	6		27								
Poa pratensis		25		6			27	53	80					
Chenopodium rubrum		20	10	12			7		20					
Eleocharis parishii		20				18								
Lemna minor		20												
Scirpus maritimus		20	70		25	36								

Species	Eas	Med	Hap	Sag	Par	Umb	Dia	Dit	Fal	Fdp	Pat	Swi	Iso	Oso
Berula erecta		10				9								
Eleocharis rostellata		10	40			18								
Ruppia maritima		10												
Sarcobatus vermiculatus		10	20		25	55					100	80	67	
Solidago occidentalis		10		59		9	73	65	100					
Zannichellia palustris		10												
Hordeum jubatum			100	53		55	80	41	80					
Triglochin maritima			50		25	36								
Puccinellia fasciculata			30			9								
Aster frondosus			20	6				18						
Asclepias fasciullaris			10				7							
Aster sp.			10											
Bassia hyssopifolia			10											
Centaurium exaltatum			10			18								
Lactuca serriola			10				13	6	80					
Melilotus albus			10					6						
Muhlenbergia asperfolia			10	6		46								
Ranunculus cymbalaria var. *saximontanus*			10											
Tamarix pentandra			10				33		100					
Plantago major var. *pachyphylla*				76			47	59	20					
Populus fremontii				71			67	82		40				
Juncus balticus				59			87	71	100					
Trifolium hybridum				59			47	41	40					
Beckmannia syzigachne				53				13	29					
Rumex maritimus				41			33	6						
Artemisia biennis				29			47	41	20					
Bidens cernua				29			7	6						
Conyza canadensis				29			67	41	60					
Gnaphalium palustre				29			7	6						
Polygonum hydropiperoides			29			7	6							
Elymus triticoides				24			87	88	80	80			7	
Mentha arvensis				24			47	35	100					
Potentilla rivalis var. *millegrana*				24			33	29						
Rorippa curvisiliqua				24			7							
Agrostis stolonifera				18			40	71						
Alopecurus geniculatus				18			7							
Callitriche palustris				18										
Hordeum brachyantherum				18			40	12	80					
Polygonum argyrocoleon				18			33	29						
Carex sp.				12				12						
Cirsium vulgare				12			47	47	100					
Cypselea humifusa				12			7							
Juncus bufonius				12										
Matricaria maritima				12										
Plagiobothrys stipitatus var. *micranthus*			12			7								
Polygonum persicaria				12			13	6						
Sonchus asper				12			13	6	60					
Veronica peregrina var. *xalapensis*				12			13		20					

Species	Eas	Med	Hap	Sag	Par	Umb	Dia	Dit	Fal	Fdp	Pat	Swi	Iso	Oso
Amaranthus californicus				6										
Bromus carinatus				6			40		80					
Cardaria pubescens				6			20		20					
Carex athrostachya				6				24						
Cirsium sp.				6										
Cuscuta sp.				6										
Equisetum arvense				6			7	47						
Gnaphalium microcephalum				6										
Juncus nevadensis				6			7							
Limosella aquatica				6										
Plagiobothrys scouleri				6										
Poa sp.				6										
Polygonum coccinium				6				6	40					
Ranunculus gmelinii				6			7							
Ranunculus sceleratus var. *multifidus*				6										
Salix sp.				6			7							
Sida hederacea				6			7	6						
Verbena bracteata				6				6						
Allenrolfea occidentalis					50	9								
Atriplex sp.					25		7							
Atriplex torreyi					25	55					20			
Poa juncifolia						36								
Chrysothamnus nauseosus ssp. *hololeucus*						9							27	
Cordylanthus maritimus var. *canescens*						9								
Sarcobatus baileyi						9					20	80	33	100
Artemisia ludoviciana							27	12	100					
Eleocharis pauciflora							27	12						
Carex nebraskensis							13	6						
Cirsium arvense							13	24						
Shepherdia argentea							13	12						
Sisymbrium altissimum							13		20				33	
Ambrosia acanthicarpa							7							
Carex rostrata							7							
Descurainia sophia							7	6						
Iva axillaris							7						33	
Lepidium latifolium							7	24	60					
Lepidium virginicum							7							
Lindernia dubia							7							
Lotus tenuis							7							
Oenothera flava							7	6						
Salsola australis							7				40		87	
Tanacetum vulgare							7	6						
Taraxacum officinale							7	24	40					
Thlaspi arvense							7							
Arabis sp.								6						
Bromus rubens								6						
Bromus tectorum								6					33	
Carex lanuginosa								6						
Chenopodium album								6					7	
Chenopodium botrys								6						

Species	Eas	Med	Hap	Sag	Par	Umb	Dia	Dit	Fal	Fdp	Pat	Swi	Iso	Oso
Echinodorus rostratus								6						
Medicago sativa								6						
Verbascum thapsus								6						
Atriplex patula									20					
Carex praticola									20					
Cichorium intybus									20					
Medicago hispida									20					
Artemisia tridentata ssp. *tridentata*										100	20			
Chrysothamnus nauseosus ssp. *consimilans*										40				
Chenopodium sp.										20				
Cleomella obtusifolia										20				
Sporobolus airoides										20				
Atriplex canescens											80		93	
Ariplex confertifolia											60	100	20	100
Dalea polyadenia											20		47	
Halogeton glomeratus											20			
Tetradymia sp.											20			
Stanleya pinnata												40		
Tetradymia canescens												20	87	
Tetradymia glabrata												20	7	
Oryzopsis hymenoides													100	
Abronia turbinata													60	
Tiquilia nuttallii													47	
Artemisia tridentata ssp. *wyomingensis*													40	
Eriogonum brachyanthum													20	
Phacelia bicolor													20	
Euphorbia ocellata													13	
Chrysothamnus parryi													7	
Gilia leptomeria var. *micromeria*													7	
Grayia spinosa													7	
Sphaeralcea ambigua													7	
Artemisia spinescens														20
Kochia americana														20
Pectis papposa														20

Soil Type Key:

Eas = East Fork
Med = Medifibrists
Hap = Haplaquents
Sag = Sagouspe
Par = Parran
Umb = Umberland
Dia = Dia
Dit = Dithod
Fal = Fallon
Fdp = Fallon, drained-phase
Pat = Patna
Swi = Swingler
Iso = Isolde
Oso = Osobb

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As part of a national study, vegetation associated with known hydric and nonhydric soil series was sampled in Lyon County, Nevada. Weighted averages and presence/absence averages were calculated for vegetation in each soil series using the method developed by T.R. Wentworth and G.P. Johnson at North Carolina State University. The wetland indicator status for each plant species was determined using the Wetland Plant List developed by the U.S. Fish and Wildlife Service. This technique was effective in delineating nonhydric from hydric soils in a disturbed condition, but where soils were flooded as a result of downstream impoundments, vegetation on all soils developed wetland vegetation. Independent measures of groundwater hydrology were also verified on the study sites and used to verify the hydric nature of soils. Relations of soils and vegetation on salinity were also discussed in relation to moisture gradients in emergent wetlands.

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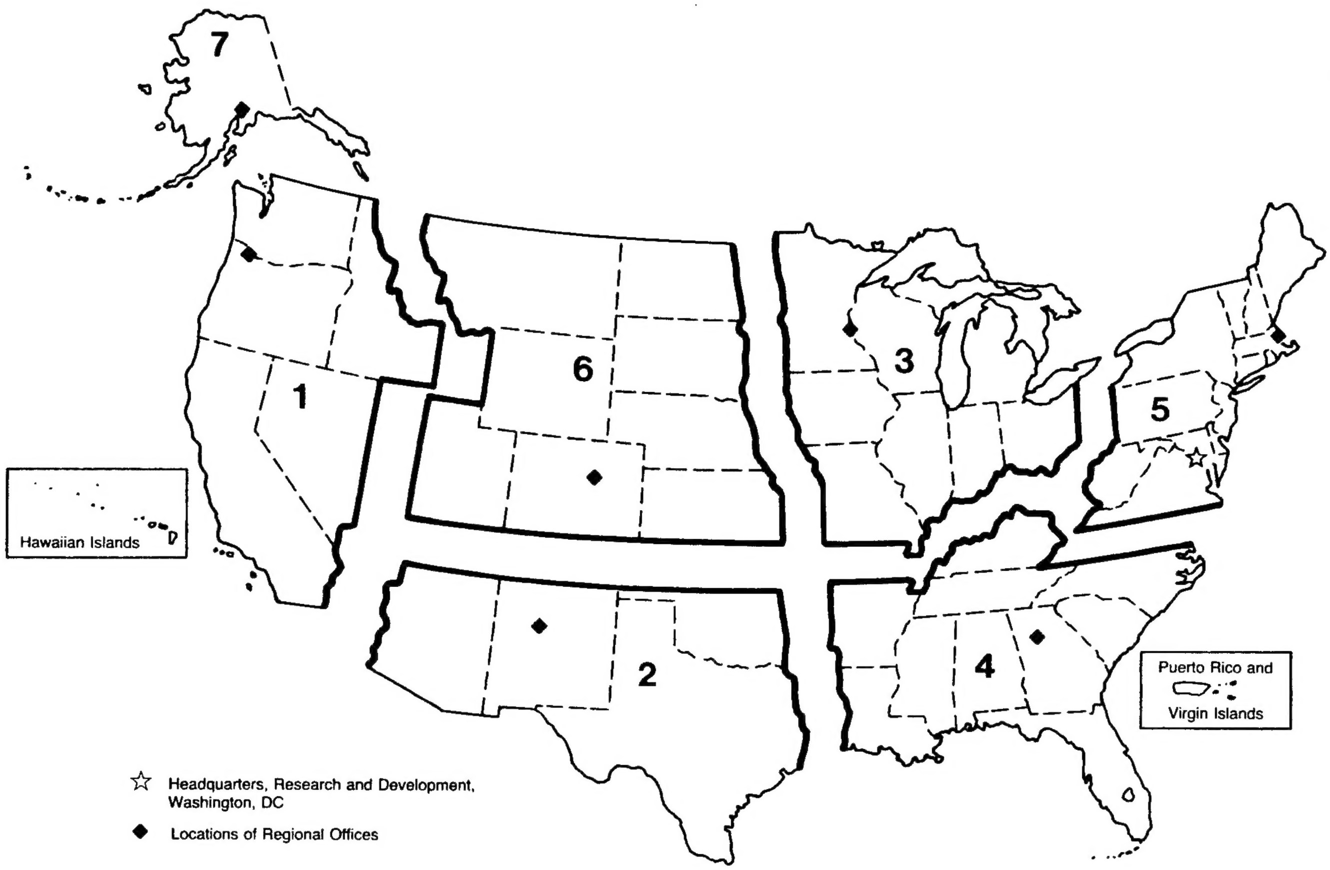

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